BUILD THIS

ACTIVE ANTENNA

When fate or nasty neighbors prevent you from stringing a long-wire receiving antenna, you'll find that this pocket-size active antenna will give the same, or even better, reception.

RODNEY A. KREUTER

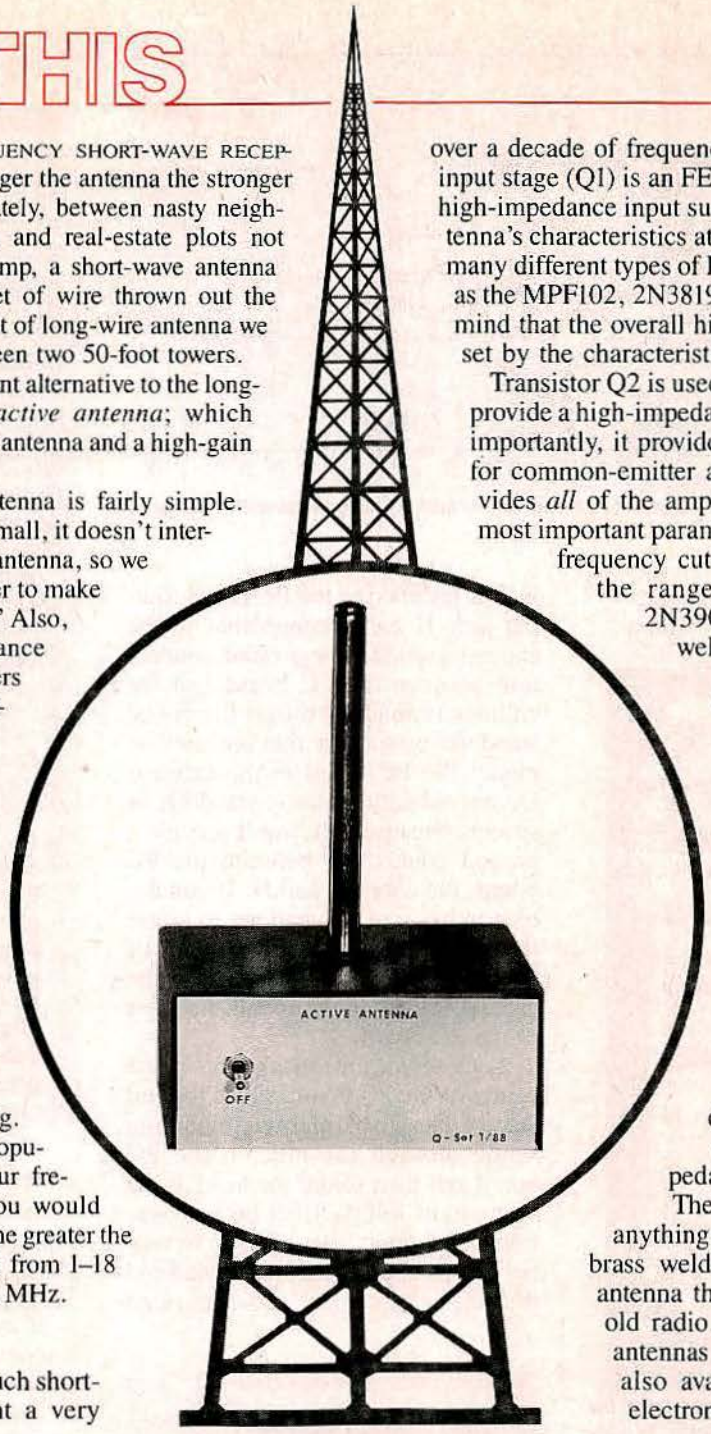
FOR CONVENTIONAL ALL-FREQUENCY SHORT-WAVE RECEPTION, the general rule is "the longer the antenna the stronger the received signal." Unfortunately, between nasty neighbors, restrictive housing rules, and real-estate plots not much larger than a postage stamp, a short-wave antenna often turns out to be a few feet of wire thrown out the window—rather than the 130 feet of long-wire antenna we would really like to string between two 50-foot towers.

Fortunately, there's a convenient alternative to the long-wire antenna, and that's an *active antenna*; which basically consists of a very short antenna and a high-gain amplifier.

The concept of an active antenna is fairly simple. Since the antenna is physically small, it doesn't intercept as much energy as a larger antenna, so we simply use a built-in RF amplifier to make up for the apparent signal "loss." Also, the amplifier provides impedance matching, because most receivers are designed to work with a 50-ohm antenna.

Active antennas can be built for any frequency range, but they are more commonly used from VLF (10 kHz or so) to about 30 MHz. The reason for that is because full-size antennas for those frequencies are often much too long for the available space. At higher frequencies, it is quite easy to design a relatively small high-gain antenna.

The active antenna shown in Fig. 1 provides 14–20 dB gain at the popular short-wave and radio-amateur frequencies of 1–30 MHz. As you would expect, the lower the frequency the greater the gain. A gain of 20 dB is typical from 1–18 MHz, decreasing to 14 dB at 30 MHz.



Circuit design

Because antennas that are much shorter than ¼ wavelength present a very small and highly reactive impedance that is dependent on the received frequency, no attempt was made to match the antenna's impedance—it would prove too difficult and frustrating to match impedances over a decade of frequency coverage. Instead, the input stage (Q1) is an FET source-follower, whose high-impedance input successfully bridges the antenna's characteristics at any frequency. Although many different types of FET's may be used—such as the MPF102, 2N3819, or the 2N4416—bear in mind that the overall high-frequency response is set by the characteristics of the FET amplifier.

Transistor Q2 is used as an emitter-follower to provide a high-impedance load for Q1, but more importantly, it provides a low drive impedance for common-emitter amplifier Q3, which provides *all* of the amplifier's voltage gain. The most important parameter of Q3 is f_T, the high-frequency cut-off, which should be in the range of 200–400 MHz. A 2N3904, or a 2N2222 works well for Q3.

The most important of Q3's circuit parameters is the voltage drop across R8: The greater the drop, the greater the gain. However, the passband decreases as Q3's gain is increased.

Transistor Q4 transforms Q3's relatively moderate output impedance into a low impedance, thereby providing sufficient drive for a receiver's 50-ohm antenna-input impedance.

The antenna can be almost anything; a long piece of wire, a brass welding rod, or a telescopic antenna that was salvaged from an old radio. Telescopic replacement antennas for transistor radios are also available from most retail electronic-parts distributors.

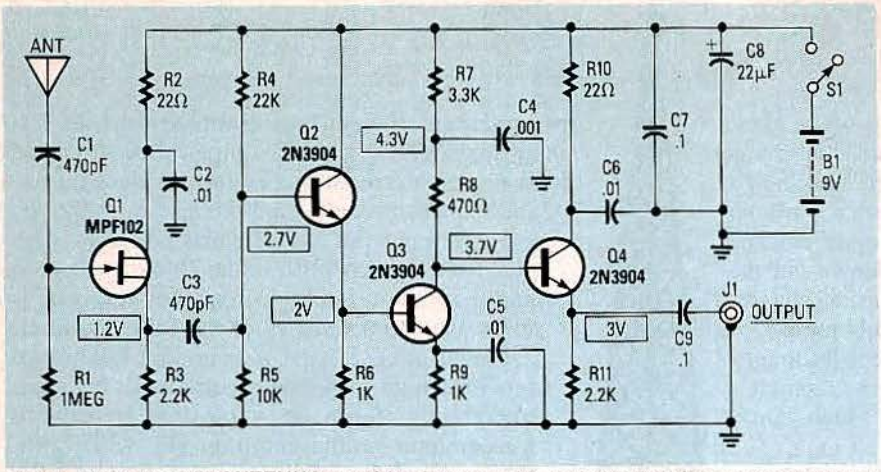


FIG. 1—THIS ACTIVE ANTENNA provides between 14- and 20-dB gain over the range of 1–30 MHz.

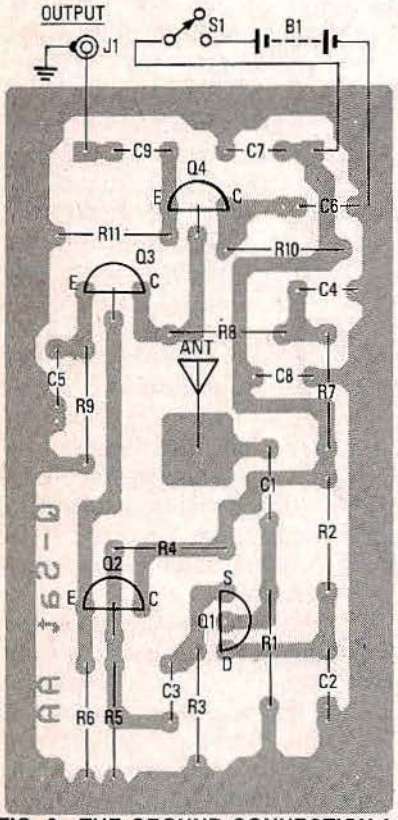


FIG. 2—THE GROUND CONNECTION for J1 is the metal cabinet. The cabinet is connected to the PC board's ground by the metal spacers at each mounting screw.

Construction

The amplifier for the prototype unit uses a printed-circuit board, for which a template is provided in "PC Service." The amplifier can be assembled on a perforated wiring board, but because there is *some* sensitivity to the parts layout, we strongly suggest that you use a PC board for best results.

The parts-placement diagram is shown in Fig. 2. Take note that although the battery's negative (ground) lead is returned to the PC board, output-jack J1 has a connection to the cabinet ground. The ground connection between the PC board and the cabinet is made through the metal standoffs or spacers that are used to mount the PC board in the cabinet. Do not substitute plastic standoffs or spacers because they won't provide a ground connection between the PC board, the cabinet, and J1. If you decide to use a plastic cabinet to house the amplifier, make certain that J1's ground connection is returned to the ground foil running around the edge of the PC-board.

A telescopic antenna mounts in the center of the PC board. From the foil side of the board, pass its mounting screw through the hole in the PC board and then solder the head of the screw to its foil pad. For both insulation and support, use a plastic or rubber grommet between the antenna and the hole in the cabinet's cover through which the antenna passes. In a pinch, several turns of a good-quality plastic tape wrapped around the antenna's shaft can be substituted for the rubber grommet.

If you decide to make provision for a wire antenna, install a 5-way binding post on the cabinet. Then, be sure to connect a short length of wire between the antenna's foil pad and the binding post.

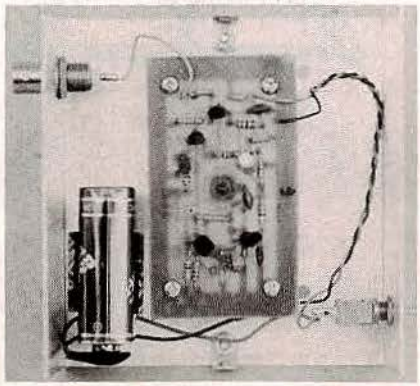


FIG. 3—THE AMPLIFIER IS SO SMALL that it almost gets lost in a 4-inch × 4-inch metal cabinet. The battery is held in place with a U-clamp. The output jack is anything that matches the receiver's antenna connection.

PARTS LIST

Resistors ¼-watt, 10%
R1—1 megohm
R2, R10—22 ohms
R3, R11—2200 ohms
R4—22,000 ohms
R5—10,000 ohms
R6, R9—1000 ohms
R7—3300 ohms
R8—470 ohms
Capacitors rated at least 16-WVDC
C1, C3—470 pF
C2, C5, C6—0.01 µF
C4—0.001 µF
C7, C9—0.1 µF
C8—22 µF, electrolytic
Semiconductors
Q1—FET, MPF102 or 2N3918 (see text)
Q2, Q3, Q4—NPN transistor, 2N3904, or equivalent
Other components
B1—9-volt battery
J1—Jack to match receiver cable
S1—SPST switch
ANT—Telescopic antenna or wire
Miscellaneous: Cabinet, printed-circuit materials, solder, etc.
Note: The following can be ordered from Q-Sat, P.O Box 110, Boalsburg, PA 16827: A printed-circuit board, $6 plus $1 shipping and handling; a complete kit (less case, switch, battery, and connectors), $15 plus $2 shipping and handling. Pennsylvania residents must add appropriate sales tax.

Modifications

If you are interested in a smaller frequency range than 1–30 MHz, resistor R1 can be replaced with an LC circuit tuned to the center of the desired range. The LC circuit will also improve the rejection of signals outside your range of interest, but remember that it won't improve the gain of the amplifier.

If your particular interest is the very-low frequencies (VLF), the amplifier's low-frequency response can

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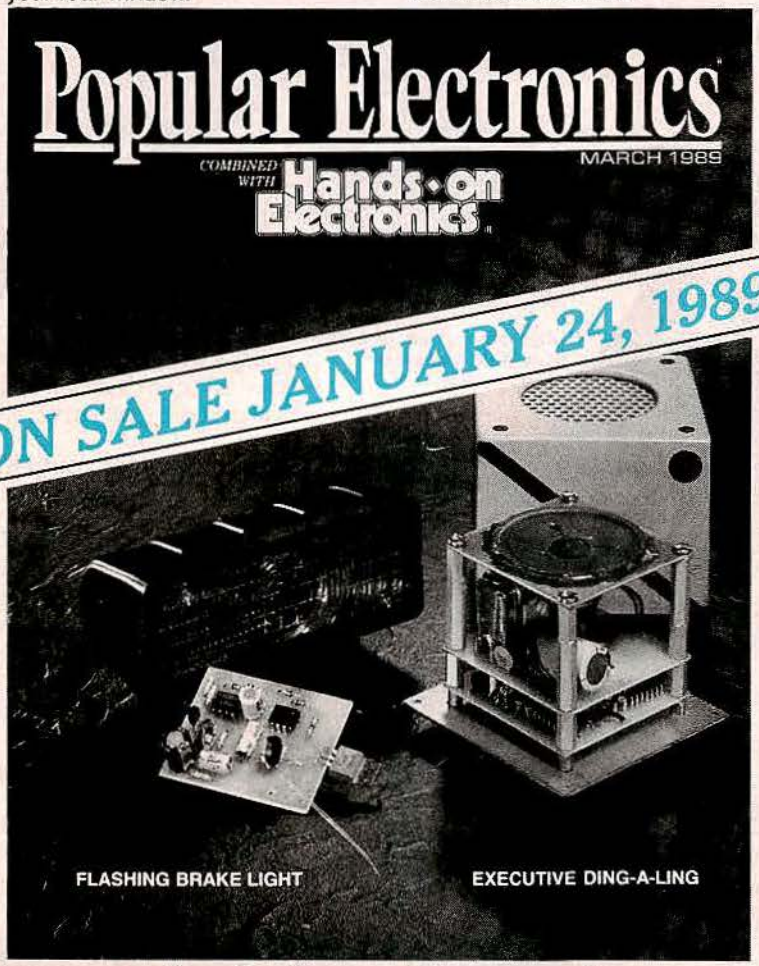

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be improved by increasing the values of capacitors C1 and C3. (You'll have to experiment with the values.)

Although a 9-volt battery is the recommended power source, the amplifier should work well using 6–15 volts. The inside of the cabinet of the completed prototype, using a 9-volt battery as the power supply, is shown in Fig. 3.

Troubleshooting

Circuit voltages for a 9-volt power supply are shown in Fig. 1. If the voltages in your unit differ by more than 20% from those in the schematic, try changing resistor values to get the voltages in their proper range. For example, if the voltage drop across R8 measures only 0.3 volt, you must decrease R4's value (the exact value is up to you to figure out) in order to increase Q3's base voltage and collector current.

The only critical voltages are those across R3 and R8. Performance should be fine if they are even close to the values on the schematic. If you decide to operate the amplifier from other than 9 volts, the values of R3 and R4 must be modified to obtain the indicated voltages.

Since it's almost impossible to measure the voltage from the gate to the source (VGS) of an FET, you can measure the voltage that is present across R3, because it is the same as VGS. Adjust R3's value accordingly, if the voltage is not within the range of 0.8–1.2 volts.

Limitations

Use of the amplifier above 30 MHz is not recommended because of sharply reduced gain. While operation above 30 MHz can be accomplished by using tuned circuits in place of the resistive loads, that modification is beyond the scope of this article. Therefore, such modifications are purely experimental.

Take care when handling the FET (Q1). A common belief is that FET's and CMOS devices are safe from static damage after having been installed in a circuit, or after being mounted to a PC board. Although it's true that they are better protected from static electricity when installed in a circuit, they are still susceptible to damage by static; so never touch the antenna before discharging yourself to ground by touching some grounded metallic object. **R-E**